# The Cyber Omelette

A personal DIY journal. Have fun and make things.

October 30, 2016

## Astrophotography Manual Barn Door Tracker

### Motivation

After seeing some beautiful photos of the milky way, I wanted to step up my astrophotography game a little bit. In astrophotography, you are limited to shutter speed = 500 / (focal length) before your stars get blurry from the earth's rotation. To get better photos of the night sky, you can use what is called a tracker which allows you to take much longer exposures.

They are also quite expensive, and not particularly complicated. So I decided to try making one myself. The goal was to make it simple, and cheap. In the end, the total was less than $50, and the results have been quite successful.

It was so simple to build in fact, you probably don't even need a guide once you understand the key concepts. So I'll start with the basics of how and why it works, followed by a breakdown of how I built it.

Here is the final product:

and some results:

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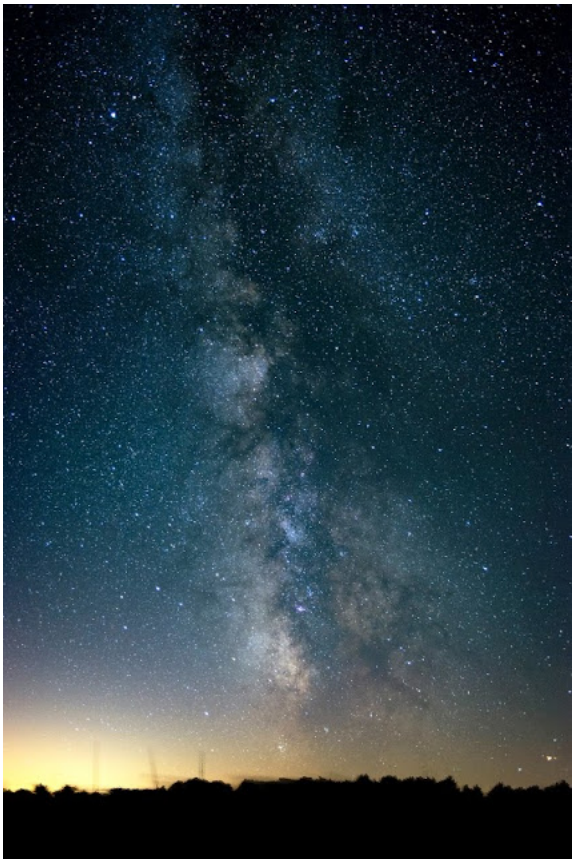
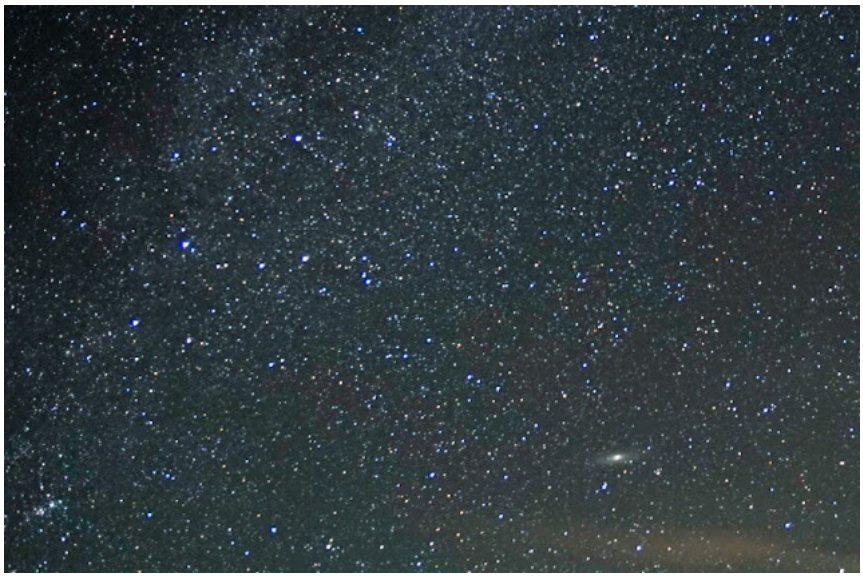


2.5 minute Milky Way exposure



Andromeda captured using 2 minute exposure

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1 minute exposure of Milky Way


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### Tracker Basics

The fundamental problem you are solving is that the earth's rotation leads to star trails as can be seen in the following photo. So all we are doing is rotating our camera opposite to the earth's movement.

Just to understand the rotation, consider long exposure with star trails as can be seen in the photo below.


Если у тебя есть компьютер - пог игру

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Example of star trails from reddit user feralfrank's post in astrophotgraphy


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Открыть

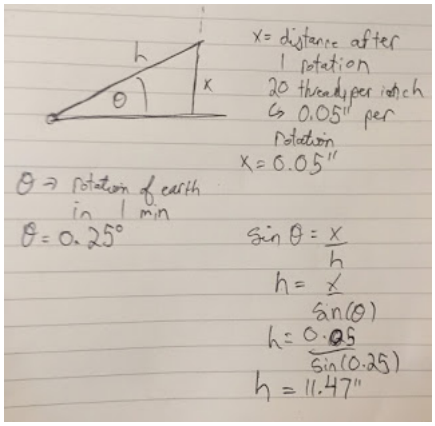

This image was taken over 2 hrs (0.083 days), during which the earth rotated 0.083 * 360 ~= 30°. To eliminate this motion, you would just have to point your camera at the center of the rotation (rotational axis), and rotate your camera ~30° over the two hour period opposite to the earth's rotation. This equates to 0.25° per minute.

I personally imagine a camera at the north pole. To align with the earth's rotation, it just needs to point straight

up. Then you place that camera in the center of a merry-go-round that spins once in 24 hrs and you've got a tracking covered.

With a barn door tracker it's the same concept, except you align the trackers rotation with the rotational axis. If you're in the northern hemisphere, this is as simple as pointing your tracker's hinge at the north star.

To drive your tracker, you will be rotating a threaded rod. As you have some flexibility in dimensions, I suggest doing some math at this stage to make things convenient for yourself if you're hand turning. I built mine such that I need to rotate the rod once per minute. With a 20 threads per inch rod, one rotation would open the tracker 0.05". A hypotenuse length of 11.47" then ensures that one rotation per minute matches the earth's rotation of 0.25° per minute.




## My build

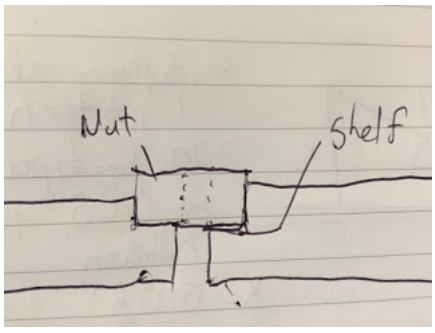
1. Tripod Head ($32)
2. 3.5" Door Hinge ($3)
3. 1 x 3/8" hex bolt ($1)
4. 1 x 1/4" 20tpi carriage bolt ($2)
5. 2 x 1/4" nut ($0.10)
6. 1 x 1/4"x20 T Nut($0.48)
7. Gorilla Glue ($7)
8. 2 x 13" 1x6 lumber - no source here as I just bought scrap wood. All you need is something that looks like the wood in my pictures, and two lengths of it

Step 1: Attach the two pieces of wood by the hinge

Step 2: Hammer the T-nut into the bottom of the wood. This is where a tripod will attach.

Step 3: Drill a hole through the board near the hinge (exact location doesn't matter), and run 3/4" bolt through to attach tripod head.

Step 4: Drill hole 11.5" from the hinge through the board for the 1/4" carriage bolt to pass through. Use a larger drill size to add a shelf to embed nut on. Gorilla glue nut to the shelf. This part is the sketchiest in my build, so use whatever you think will work to hold this nut in place.




Step 5: Thread carriage bolt up through the nut so the rounded end is in between the two sides of the hinge. Gorilla glue a nut to the end of this bolt, and glue some type of handle. I used a 3d printed handle, but literally anything you can turn would work here.

Step 6 (optional): I added two finishing nails and an elastic to prevent vibration in the hinge while turning.

And you're done!

### Usage

To use, attach your tripod to the T bolt. Adjust your tripod so the hinge of the tracker is pointing straight at Polaris and attach your camera to the mount on the tracker.

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Point your camera at whatever you want to photograph, set your shutter to bulb mode, and trigger the shutter. If your lens is 30mm or less, count out 15s and rotate the handle 1/4 turn. Repeat this for as long as you want to expose, and then release the shutter.

Different lenses will require different count / rotation amounts, so you'll have to experiment.

Posted by Ben Eagan at 3:57 PM

Labels: astrophotography, barn door, cyber omelette, DIY, hardware, high school astronomy, long exposure, milky way, photography, photos, sony a7, stars, tracker

## 10 comments:

**Avi Muchnick** December 10, 2016 at 11:37 PM

Brilliant. Can't wait to try this - thank you!

Reply

**Eugene Fisher** December 15, 2016 at 9:12 PM

Suggest adding a couple of eye hooks along the hinge for sighting on Polaris...just to stay in keeping with the hardware store theme. :)

Reply

**Ben Eagan** December 15, 2016 at 9:50 PM

Good call Eugene, thanks for the suggestion!

Reply

**Unknown** December 16, 2016 at 12:20 AM

Brilliant. Love this. Been wanting to do this for a while. Can easily add some Arduino or other compute engine to automate the process for very long steps. I wonder how this could be set up to build a heliostat - sun tracker to make sure solar panel is always perpendicular to the sun for optimal efficiency.

Reply

**C. Towne Springer** December 16, 2016 at 1:19 AM

Why no align the screw so that it passes straight through both pieces when they are together (closed?)? The screw will always be perpendicular to the bisection of theta. The doors and screw will always form an isosceles triangle and you can split that and do all calculations with a right triangle - all the time. No difference in complexity of the mechanism I think.

Reply

**Ben Eagan** December 16, 2016 at 7:15 AM

C. Towne Springer, you would have to make a moving nut in the top board in that case, as top and bottom boards wouldn't stay aligned. Tangent error really isn't a problem until 5-10 minutes in, which is really pushing the error tolerance of this build already. I recommend 2-5 min exposures.

Reply

**Evan Ahrendt** February 11, 2018 at 9:08 PM

Just finished this today. I had a lot of different kinks to work out. I am also planning to set this up with a 50mm lens so we'll see what rotations and timing I'll have to do. Any recommendations?

Reply

**Ben Eagan** February 12, 2018 at 8:00 AM

Hey Evan, anything you got stuck on that might help other readers? Please share!

The rule of 500 says you should have about 10s before streaks are visible. So I would move it 1/6th of a rotation (60 degrees) every 10s. Might be useful to mark this out on the wood. It also just takes a bit of practice to get the motion smooth and keep vibrations at a minimum, so don't be discouraged if your first 5 shots are throw away.

Reply

Replies

**Unknown** May 8, 2019 at 7:09 AM

Hi Ben great DIY!! One question I still have is, how do you calculate rotation amounts? I got a few lenses (8,18,35, and 100mm) I would like to try all of them out.

**Ben Eagan** May 8, 2019 at 11:07 AM

So rate of rotation should be consistent regardless of the lens, but each lens will have unique characteristics before trails become visible. Since we're adjust this by hand, we also want to reduce the number of times we touch it.

So the rule of 500 says divide 500 by your lens focal length, and that's about when star trails become visible. So a 50mm can do about 10s. I use that as a ballpark on how often to turn the handle, so I'm adjusting it at least every 10s.

Keep in mind you want to turn it 360 degrees exactly once per minute, so finding easy fractions to break that up is really useful. So I would personally choose to make 8 turns per minute of 45 degrees. Those would happen every 7.5s (60/8). It sounds hard, but thanks to the additive property of light while the shutter is open, you have a little bit of room for error.

The 8-35mm lenses should be great for this, but you will probably have trouble keeping things stable enough for the 100mm. Good luck!

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